Title: Performance of production models on simulated data

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Abstract:
The performance of a simple, lumped biomass production model and an age structured production model were evaluated through a factorial simulation. Factors explored were life history, CPUE trend, selectivity of fisheries, and length of time series. The simulated data consisted of 2 unaged catch series, 2 effort series, and an abundance of index. Various set-ups and constraints of each production model were tested on the simulated data. The simple surplus production model was evaluated with respect to: whether the shape parameter (defining the position of Bmsy with respect to B0) was estimated or fixed at 0.5 (logistic form); whether the model was fit with or without the index of abundance; whether the level of biomass in the first year of observations relative to virgin biomass (B1/K) was estimated or fixed to one. The age-structured production model was evaluated with respect to: whether or not a Bayesian prior was imposed on natural mortality (M) and maximum lifetime fecundity (α); whether the model was forced to estimate catch better or the effort and abundance index; whether the ages of full selectivity were estimated or fixed; whether "missing historical effort" was estimated with a linearly increasing trend or a single value that was assumed to represent an average level. Considering all factor combinations, the best performance of the simple surplus production model was for the case where the shape parameter was estimated, the abundance index was included, and (for time series that started far below virgin levels) B1/K was estimated. The age structured production model performed best with a prior on M, when the model tried to fit catch better than the effort and abundance index, when ages of full selectivity were estimated, and when a linear trend in effort was fit for the "missing" historical effort. Comparing the two models side by side, a general result was that the simple surplus production model did as well as, if not better than, the age structured production model in estimating B/Bmsy, F/Fmsy, and typically outperformed the age structured model in estimating MSY. Cases where the age structured production model was very imprecise in estimating MSY were restricted to the short time series (typically with initial SPR around 25%-35%) and resulted from the model grossly overestimating virgin recruitment. For those same cases, the estimate of the ratio of current yield with respect to MSY was much more precise. The age structured production model was much more precise in estimating Bmsy/B0.

Performance of Production Models on Simulated Data

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MOTIVATION

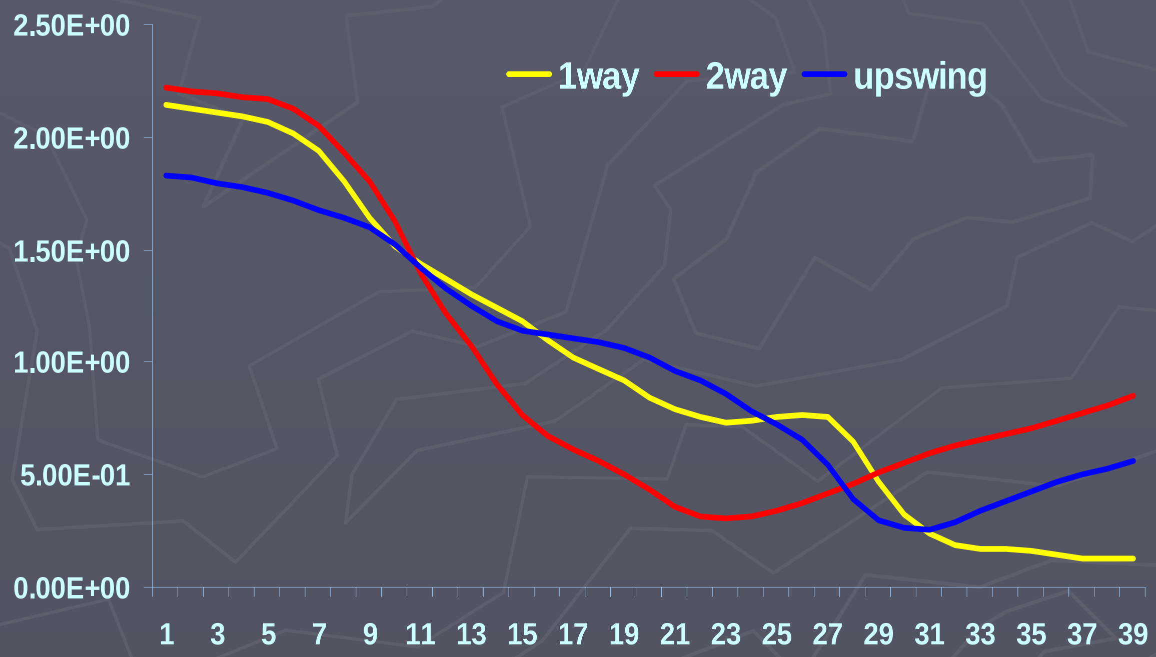
- Catch is not aged
  - Use surplus production model?
    - + Simple
    - + Low input demands
    - - Lacks biological reality
  - Use Age structured production model?
    - + Biologically realistic
    - + Model more management scenarios (effect of minimum size, e.g.)
    - - Greater input demands

FACTORIAL SIMULATION

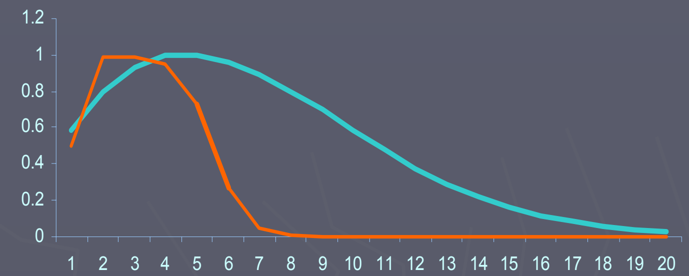
- LIFE HISTORY
  - Red Snapper (M=0.1)
  - Swordfish (M=0.2)
  - Spanish Mackerel (M=0.3)

FACTORIAL SIMULATION

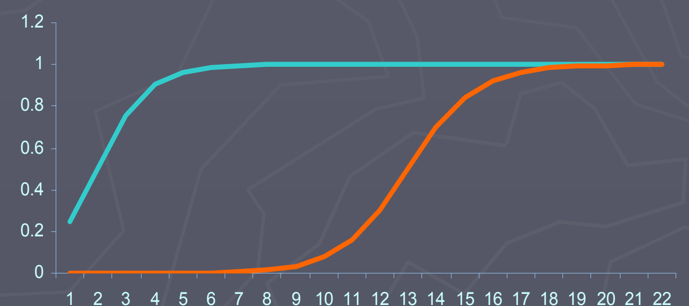
- CPUE Trend
  - 1-way trip
  - 2-way trip
  - Short upswing

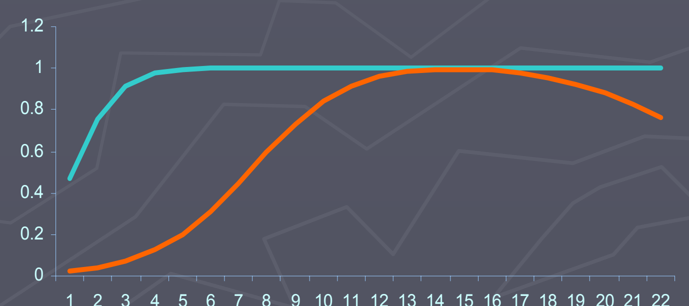


FACTORIAL SIMULATION



- **Selectivities (2 Fisheries)**
  - **2 Dome-shaped**
  - **2 Asymptotic**
  - **1 Dome-shaped, 1 Asymptotic**





FACTORIAL SIMULATION

- Length of time series
  - 2 X Generation Time (start at virgin level)
    - Red Snapper (GenTime ~ 20 yrs)
    - Swordfish (GenTime ~ 13 yrs)
    - Spanish Mackerel (GenTime ~ 7 yrs)
  - 15 years (most start at 25-35% virgin level)
    - Red Snapper
    - Swordfish

OPERATING MODEL

- FSIM (P. Goodyear)
  - 200 data sets of each factor combination
  - 21 growth "morphs"
  - Variability in recruitment
  - 2 Fisheries (Effort and Catch series)
  - Index of Absolute Abundance
  - Lognormal Observation error added post-simulation to catch, effort, index (5%-15% CV)

ESTIMATION MODELS

- ASPIC (M. Prager)
  - Catch and effort series, condition on catch
  - Fits generalized as well as logistic

- ASPM in ADModel Builder (C. Porch)
  - S-R parameterized with R0 and alpha (maximum lifetime fecundity)
  - Maturity, weight, selectivity are age-specific

RESULTS

- Comparisons of B/Bmsy, F/Fmsy, and MSY
- Calculated Proportional Error for each trial:

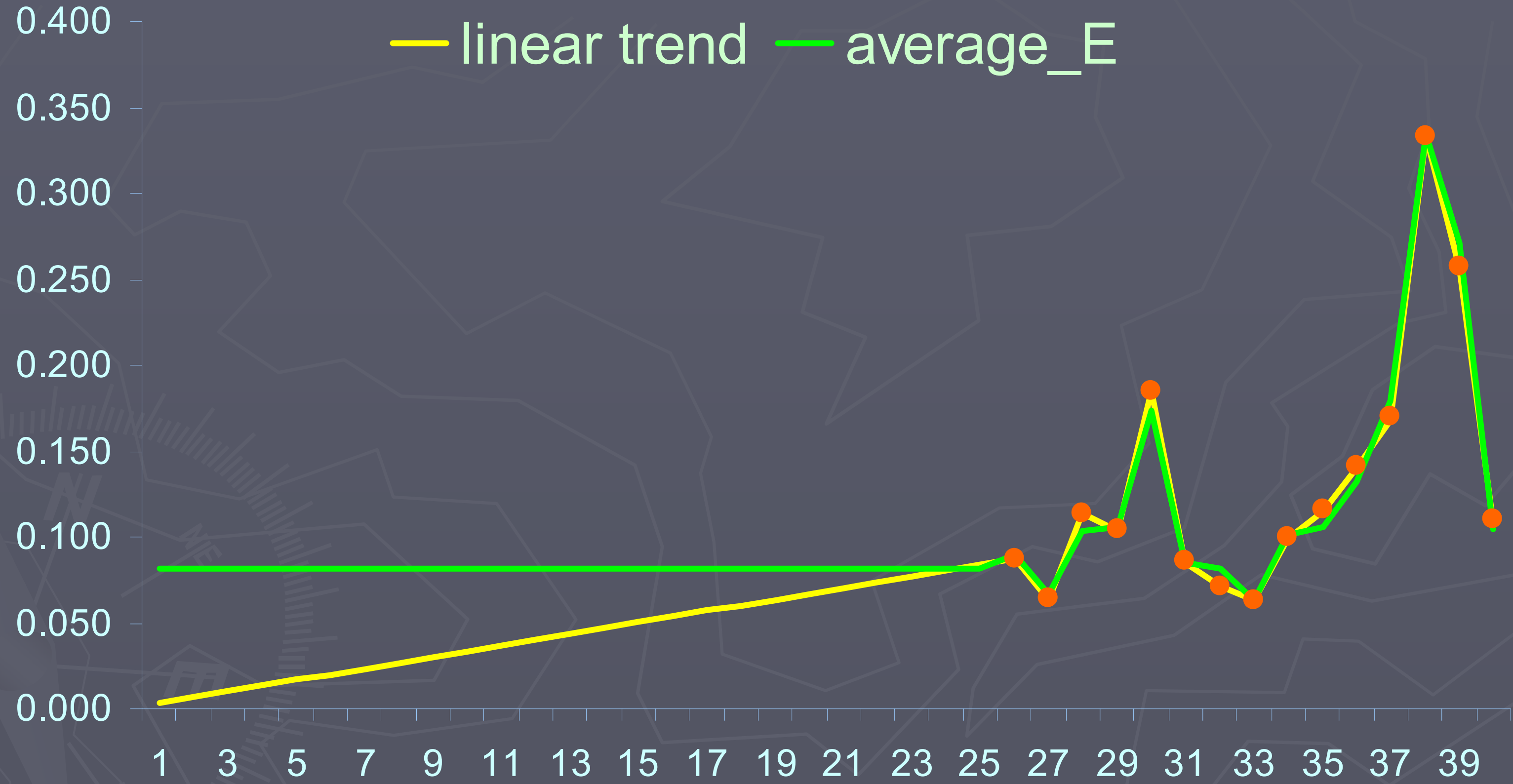
(Estimate – True) / True

Report median, 10^{th} and 90^{th} percentiles

ASPM Parameterizations

1. **Use of Priors: None, M, M and alpha**
2. **Model Fit: Catch or Effort / Index**
3. **Selectivities: Estimated or Fixed to true value**
4. **Historical effort: Linear trend in E or Ave E**

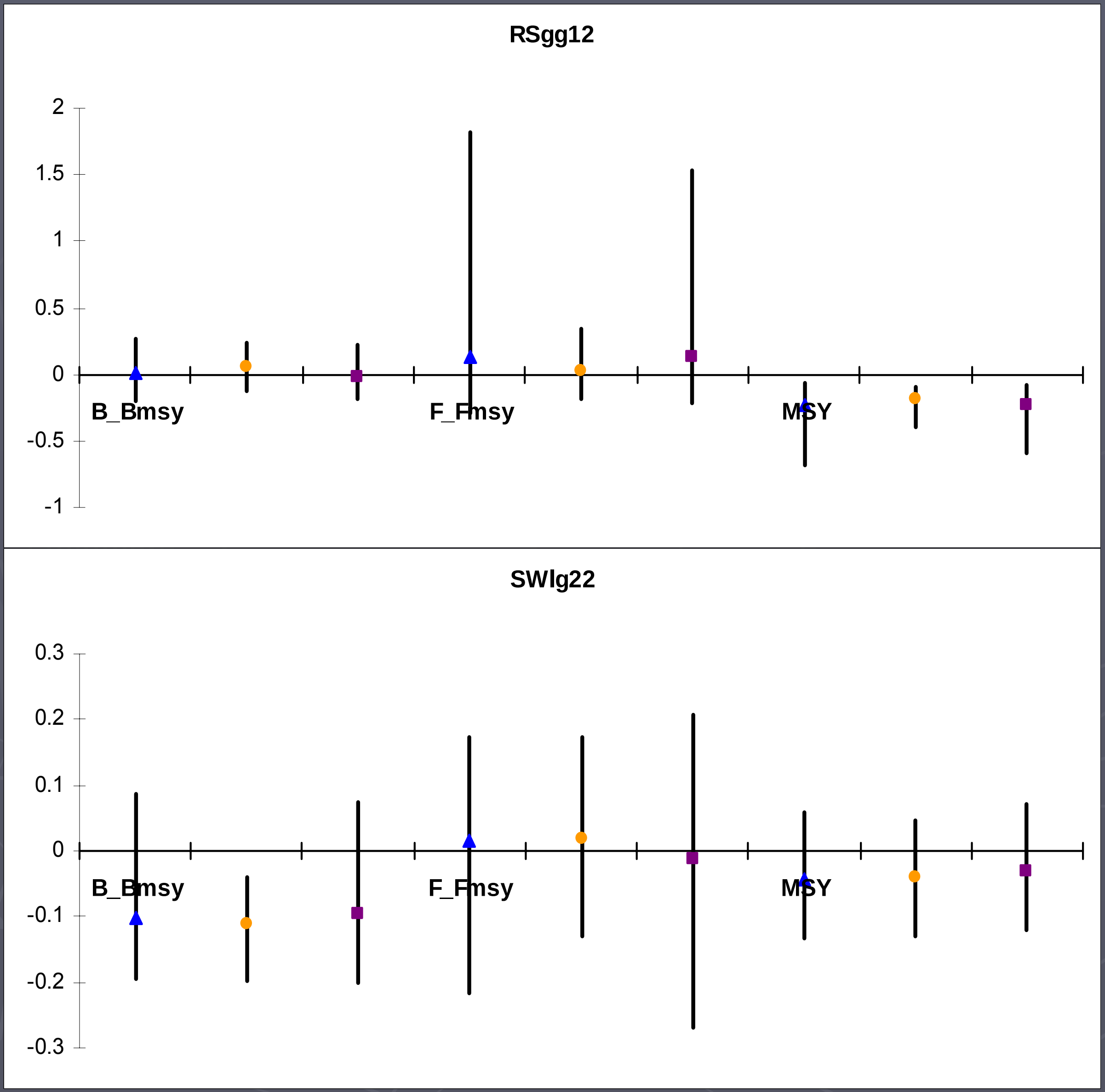
ASPM – Historical Effort Estimation



ASPM Conclusions (2xGenTime cases)

1. Use of Priors: None, M, M and alpha
   - With no priors, model performed very poorly
   - Prior on M → better performance
   - Priors on M and alpha → more precise but bias was similar
2. Allow model to fit Catch or Effort/Index
   - Precision and bias were similar

ASPM - Priors



M prior

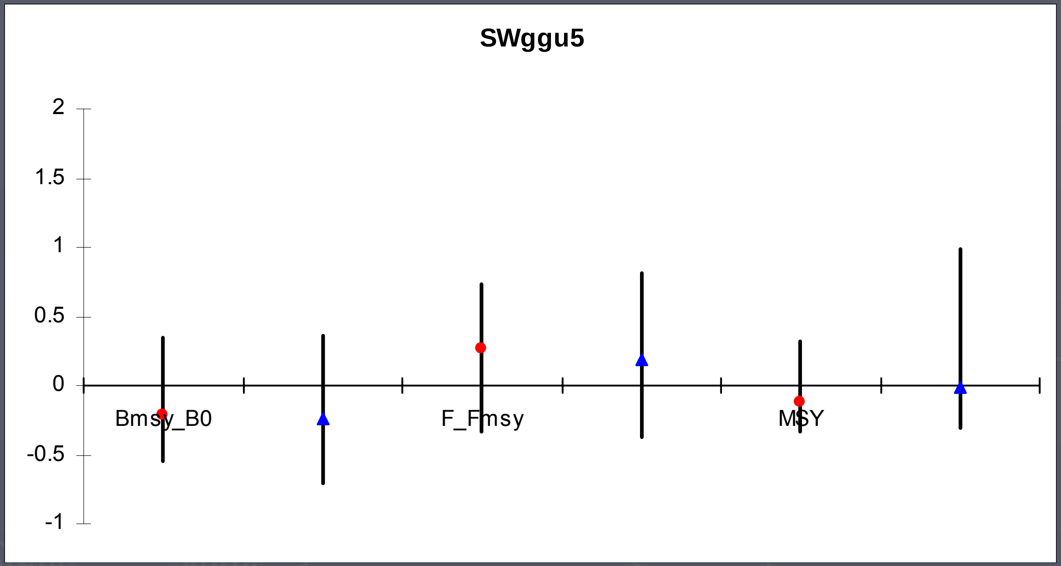
M, alpha priors

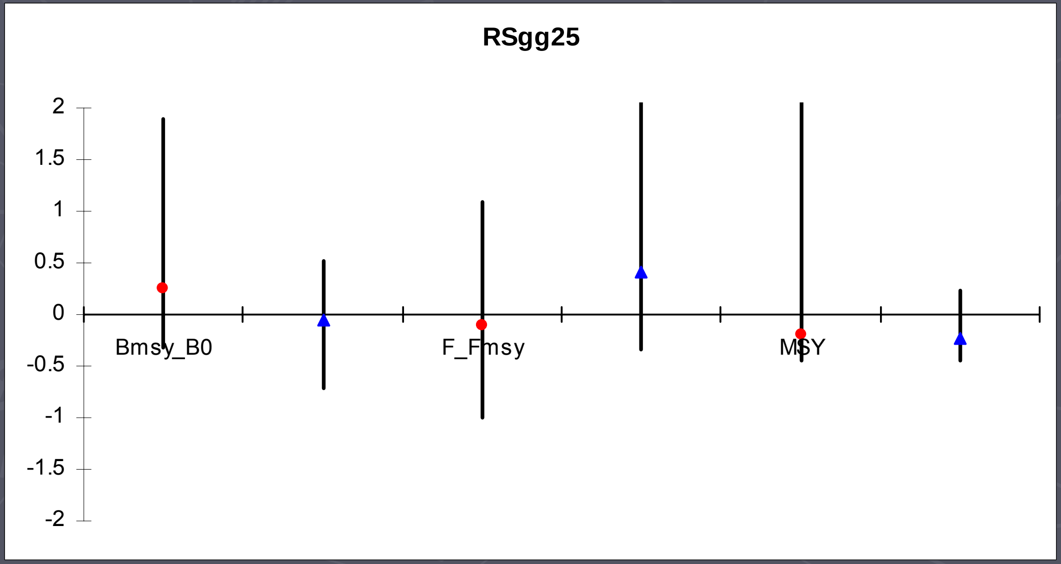
M prior, Allow better fit to Effort and Index

ASPM Conclusions (15yr cases)

3. Selectivities: Estimated or Fixed to true value
    - Slightly less bias when estimating selectivities
    - Generally similar precision
4. Historical effort: Linear trend in E or Ave E
    - Linear trend slightly better
    - Both options led to really high MSY (typically these were cases with R0 overestimated)

ASPM - Selectivity

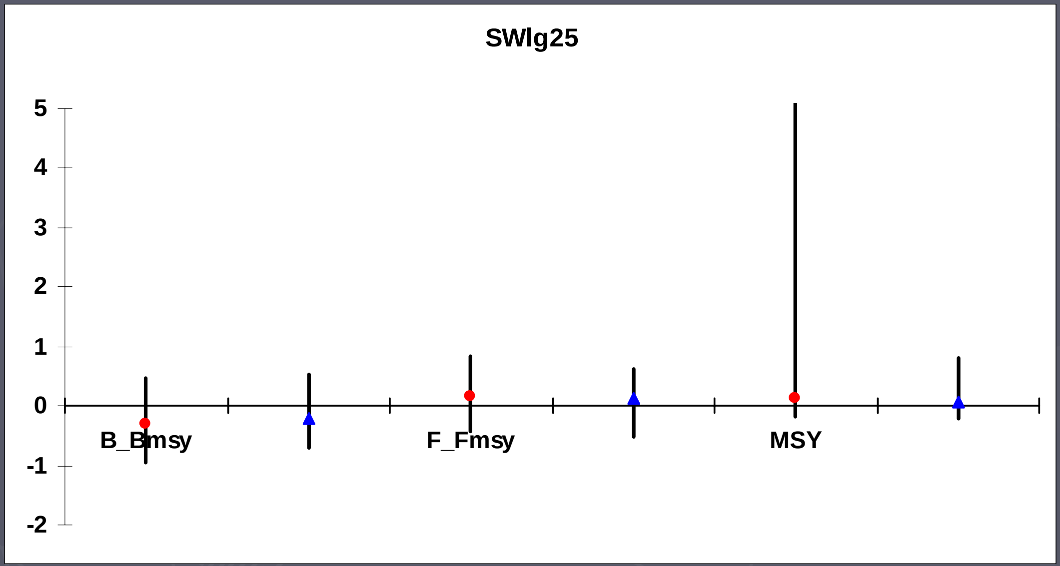


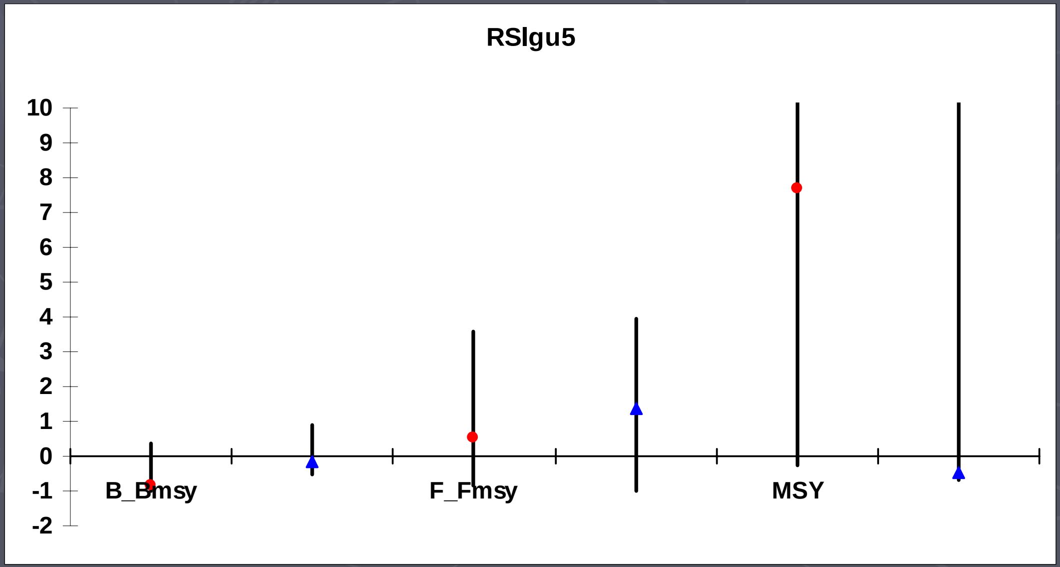


Fixing Selectivity

Estimating Selectivity

ASPM – Historical Effort





Average E

Linear E

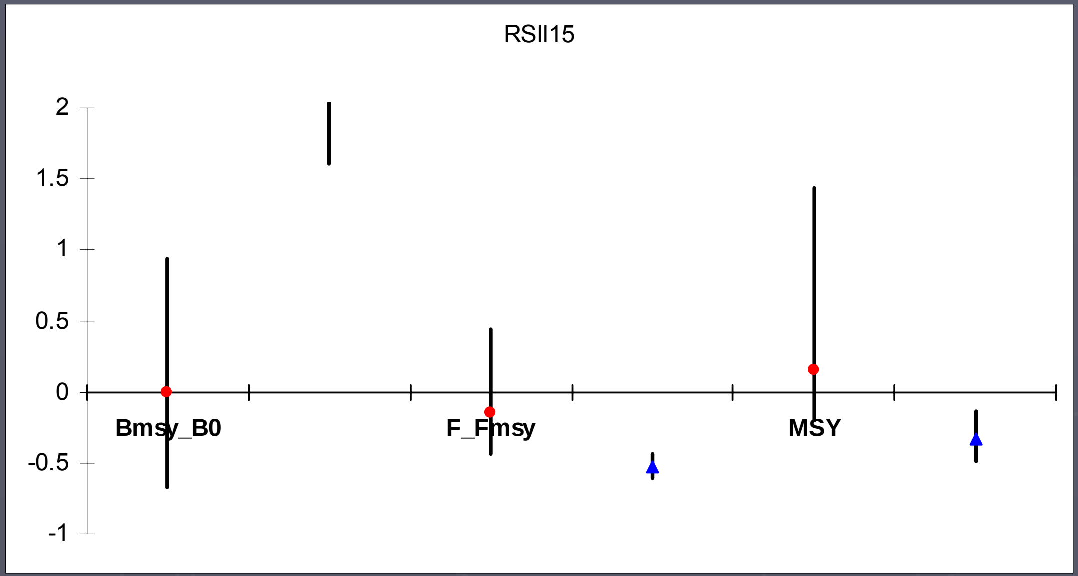
ASPIC Parameterizations

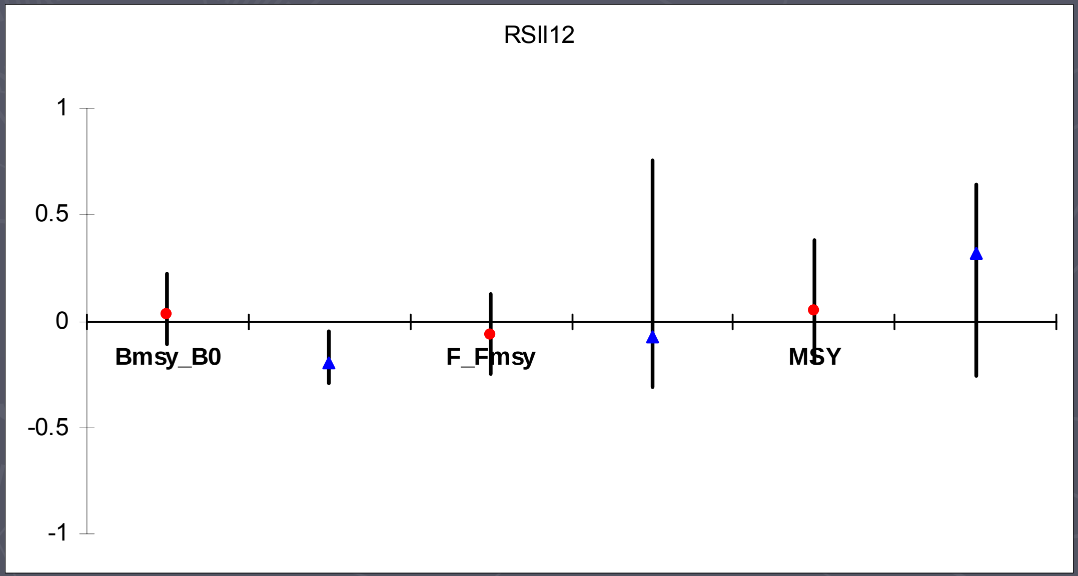
1. Fit logistic and generalized models (shape parameter bounds: Bmsy/K in 0.25-0.75)
2. Fit with and without abundance index
3. Fixing B1/K=1 or estimating B1/K (for 15yr data)

ASPIC Conclusions

1. Fit logistic and generalized models (shape parameter bounds: Bmsy/K in 0.25-0.75)
   - Logistic very biased
   - Generalized more precise, accurate
   - Shape not well estimated (*Spanish Mackerel)
2. Fit with and without abundance index
   - Very little difference (2xGenTime)
   - MSY more precise, avoids bias (15yr)

ASPIC – Generalized vs Logistic





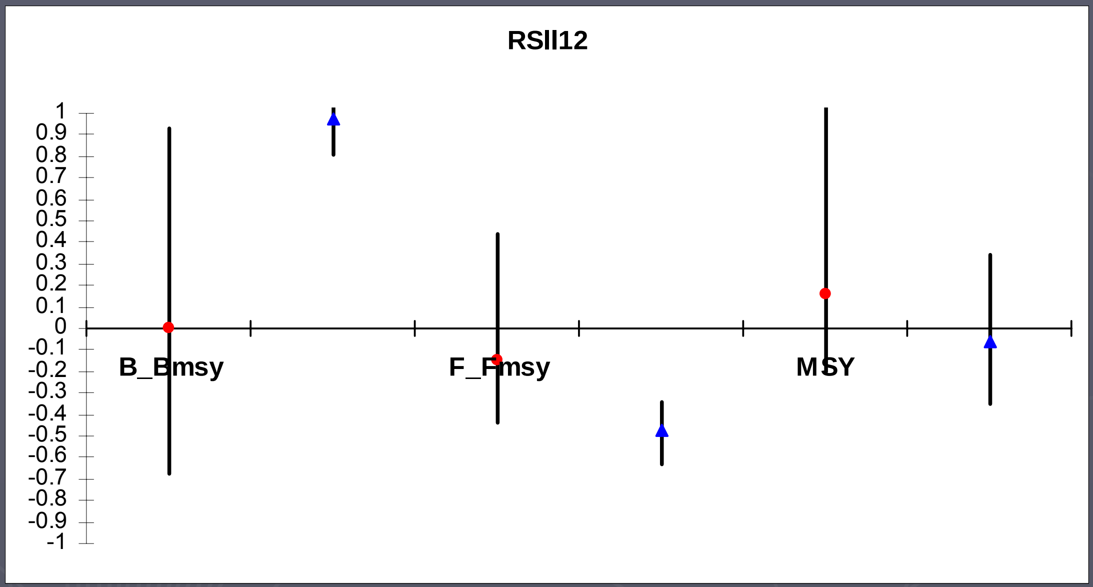
Generalized

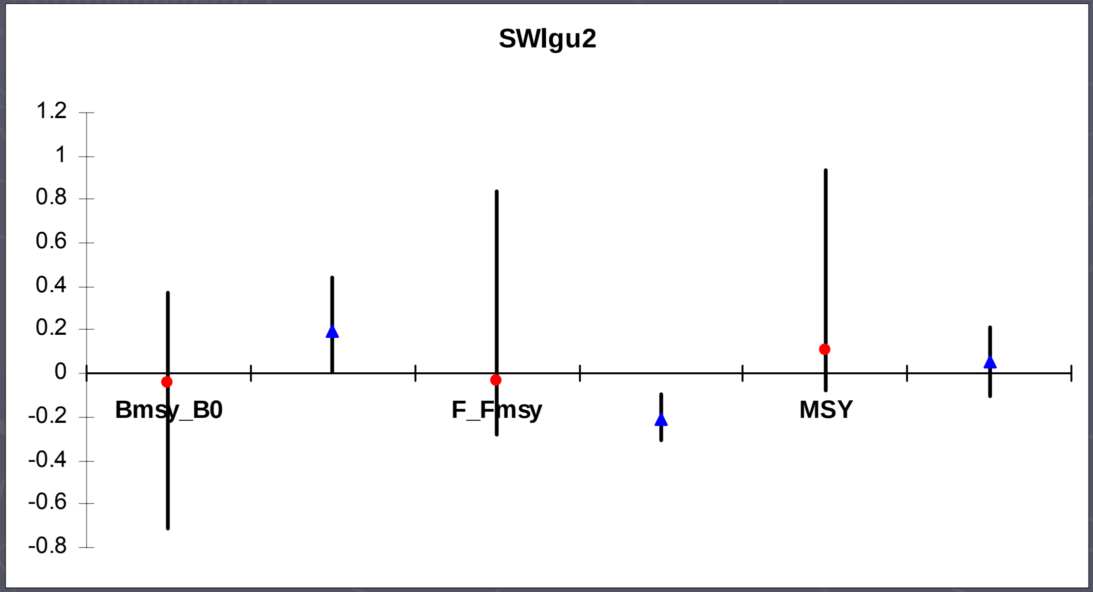
Logistic

ASPIC Conclusions cont.

3. **Fixing B1/K=1 or estimating B1/K (for 15yr data)**
   - Fixing B1/K=1 led to more precision but was typically biased

ASPIC – B1/K





B1/K estimated

B1/K Fixed = 1

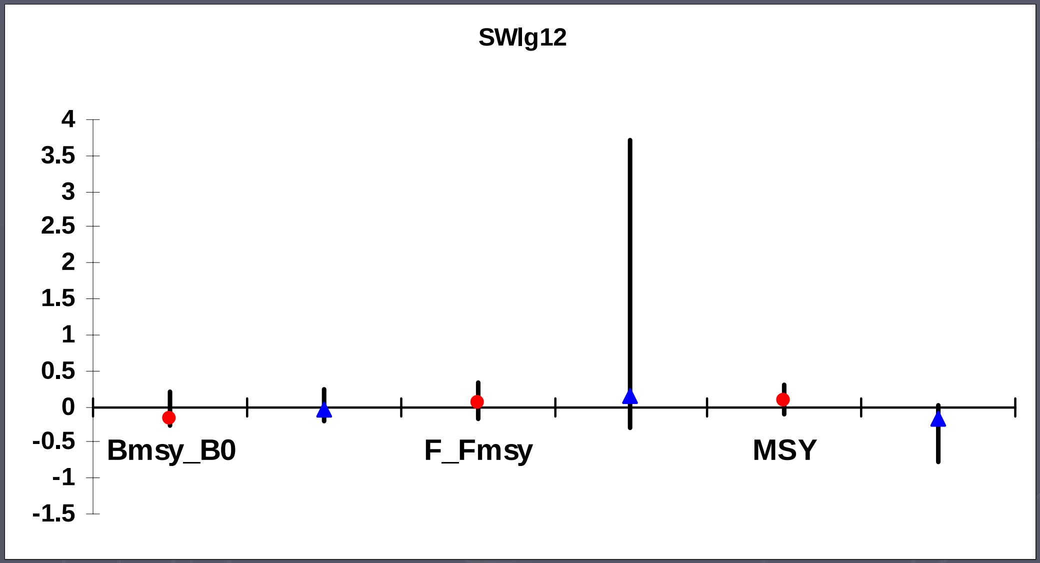
Selected Parameterization

- **ASPIC**
  - Generalized model
  - Included abundance index
  - For 15yr data, estimating B1/K
- **ASPM**
  - Prior on M only
  - Model Fit to Catch
  - Estimating selectivity
  - For 15yr data, estimating linear trend in E

ASPIC vs ASPM

- **2xGenTime cases**
  - Red snapper : 2-Gamma selectivities F ratio was less precise; similar otherwise
  - Swordfish : 1-way CPUE ASPM F ratio was less precise; upswing CPUE improved F estimate
  - Spanish mackerel : MSY in ASPM biased low; otherwise results were similar
  - Overall, ASPIC very precise and accurate on MSY and generally performed as well/better than ASPM for B and F ratios

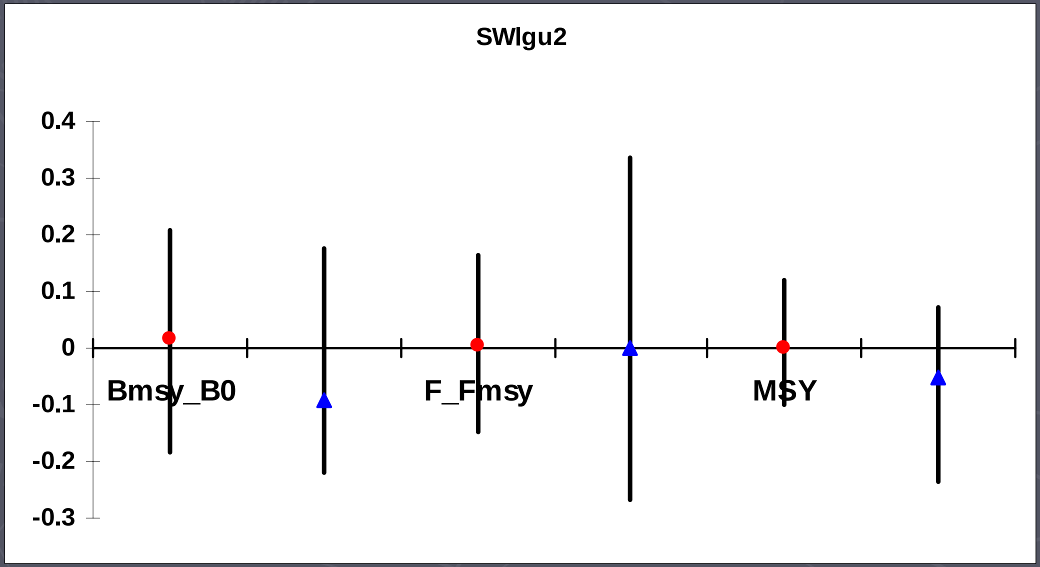
ASPIC vs ASPM – 2xGenTime



ASPIC

B1/K = 1

Generalized model



ASPM

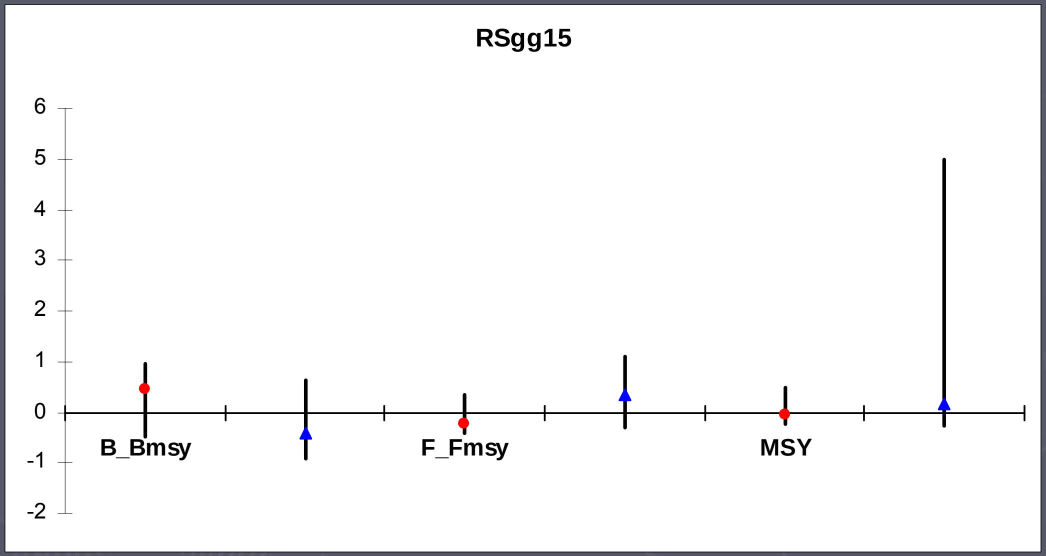
M prior only

Selectivity est.

ASPIC vs ASPM

- 15 yr cases
  - Red snapper : ASPM MSY overestimated, B and F ratios generally unbiased; large MSY due to R0 estimates being high
  - Swordfish : ASPIC and ASPM similar

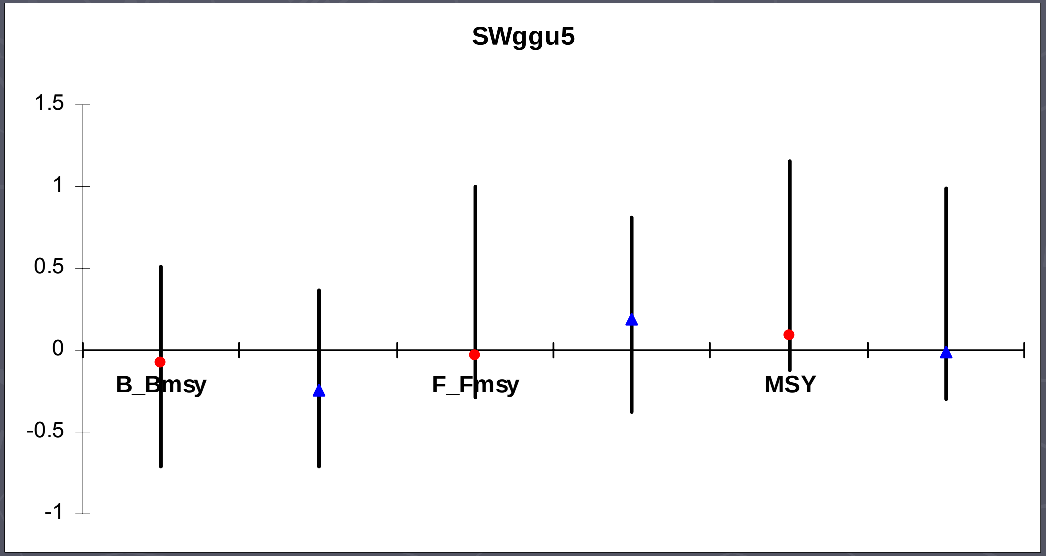
ASPIC vs ASPM – 15 years



ASPIC

B1/K estimated

Generalized model



ASPM

M prior only

Selectivity est.

Linear E trend

The End

Further work...

- Check estimates of selectivity
- Evaluate estimates of M, alpha, and R0
- Evaluate sensitivity of ASPM model to various inputs

Future Considerations

- Use of multiple models to assess, model averaging